

ORIGINAL ARTICLES

THE LIFE OF RADIUM AND ITS THERAPEUTIC USE IN INTERNAL MEDICINE.*

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You remember, that if you force a sufficient electric current through the so-called Crookes tube, that this tube will display some characteristic light effects around the anode and the kathode. As the light effects displayed around the kathode are the only ones which have any bearing on the subject which we intend to investigate to-night, I will ask your permission to recall in a few words the phenomena displaying themselves around this terminal.

The dim purple light emitted from the kathode is commonly known as the kathode ray. If you perforate the kathode with little holes, there will be another display of rays behind the kathode. These were discovered by Goldstein and are named canal or Goldstein rays. Wherever the kathode rays hit a hard body,—which in the original Crookes tube was the glass wall,—a new kind of ray is produced. These new rays with their strangely penetrative power were discovered by Professor Roentgen in 1895, and have been known since as Roentgen or X-Rays. Let me add to these well-known facts, that the canal or Goldstein rays are practically most minute corpuscles thrown from the anode and charged with positive electricity; that the kathode rays are a moving stream of negatively charged electrons, and that the invisible Roentgen rays as you have seen are secondarily produced by these visible kathode rays, and that the fluorescence of the X-Ray tube is due to the impact of the cathode stream on the glass wall.

The fact that the Roentgen rays were found to be associated with the fluorescence of the glass wall, induced the physicists to investigate, if with other fluorescent bodies, which show light displays after having been exposed to bright sunlight rays were produced which had a similar effect on the photographic plate.

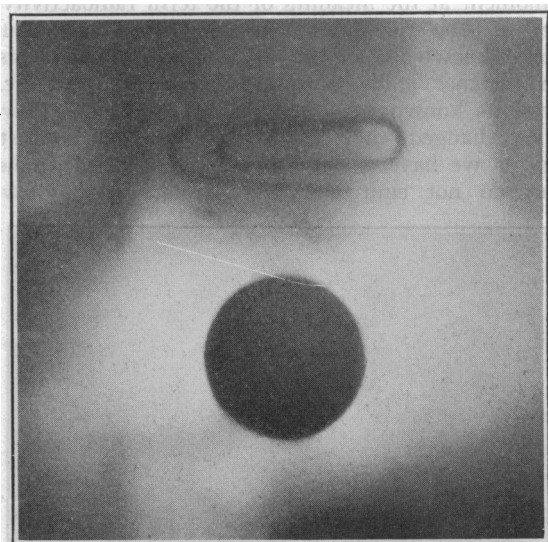
By great good fortune—and you all know what an important part great good fortune has played in quite a number of the most notable discoveries—Henry Becquerel chose as his trial phosphorescent body a preparation of uranium, which previously was exposed to sunlight and then placed upon a photographic plate wrapped in black paper. The result was that the photographic plate beneath the uranium preparation was darkened.

Picture No. 1.

Picture No. 2.

Entirely unlike the sunlight, this uranium preparation had sent out rays which penetrated the black envelope containing the photographic plate, and further experiments showed that these uranium rays would also penetrate thin plates of metal. And at this point great good fortune played again the leading part in Mr. Becquerel's experiment. For one day, the sun being obscure, the

uranium preparation could not be exposed to sunlight, and since no after-shining could be expected, the plates with the uranium preparation were set aside in a drawer. Luckily this plate was developed several weeks later, and Mr. Becquerel found that the effect on the photographic plate was exactly the same as it was after the uranium preparation had been rendered phosphorescent by previous exposure to the sunlight. From these experiments he concluded, that the emission of the effective rays from the uranium preparation had nothing to do with a previous exposure to sunlight and a subsequent after-shining, but that these effective rays were a specific property of the uranium preparation itself; further investigations showed that the power of emitting these rays was possessed by all uranium preparations quite independent of any influence from the outside. These rays with all their specific properties, emitted from the uranium, and as later found, also from the thorium preparations—have been called in honor of their discoverer—Becquerel Rays.



Picture No. 1—A photograph obtained by placing a piece of pitchblend on a coin and, a clamp, the plate and pitchblend being bound together by two strips of adhesive plaster (see text).

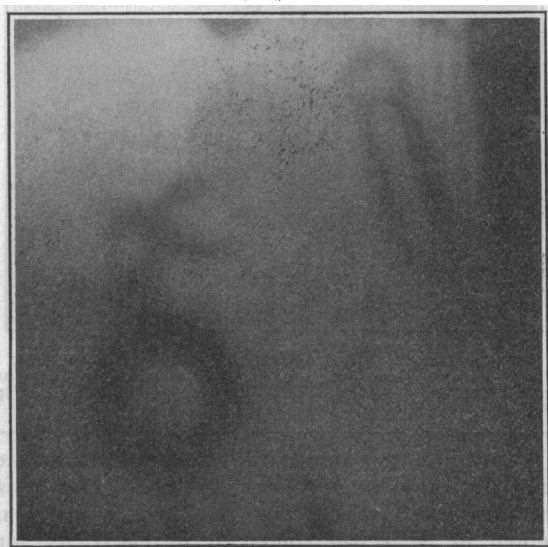
It being a well-known fact that the ultra violet rays, the kathode and Roentgen rays, would ionize the air, which means that they would make air known to be a bad conductor of electricity into a good one, the Becquerel rays were examined as to their ionizing properties, and it was found that the approach of a piece of uranium or any one of its salts would cause the leaves of a gold leaf electroscope, that had been previously charged with positive or negative electricity, to collapse, and from the velocity with which the collapse of the leaves takes place, we are able to calculate the ionizing power of the preparation in question.

M. and Mme. Curie, working at the time of Becquerel's discovery in his laboratory, undertook to investigate uranium, its different salts and the minerals containing it. Their investigations led to the most interesting and surprising discovery, that many of the uranium-containing minerals showed by far more ionizing power than the

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metal uranium itself, and the so-called pitchblend mined in Joachimsthal, in Bohemia, was found to be actually three times as ionizing as the metal uranium. The conclusion of these investigators was, that there must be some other ionizing element than uranium in the pitchblend and by chemically dividing and examining each of the so gained products as to their ionizing power, and then by further and further and still further division of these respective products they finally succeeded in separating two most effective ionizing substances, the one always accompanied by bismuth, which Mme. Curie called *Polonium*, in honor of her fatherland, Poland; the other one always accompanied by barium, which was named by her *Radium*; and it was only after treating many tons of pitchblend that Mme. Curie succeeded in producing a few decigrams of a pure Radium-chloride. The ionizing power of this radium-chloride is about a million times greater than that of uranium.

Now before proceeding any further with the properties of this new element, we will look for a moment at the meaning of the term radioactivity! Let us stop for a moment and reflect upon our stored knowledge of all our well-known elements, for instance gold, silver, lead, copper, iron; etc., elements known for hundreds of years; they have never changed, they are always the same, consisting, as we have a right to believe, of dead atoms, they do not emit any rays similar to those we



Picture No. 2—A photograph obtained by placing the mantel of a Welsbach light upon a metal ring and clamp. The Thorium in the mantel photographs the metallic objects and at the same time photographs itself as evidenced by the network effect. The shadow above the ring is due to a crack in the mantel.

have learned of, they cannot ionize the air, at least not to such an extent as to show any influence on such an extremely delicate instrument as the electroscope. And I would mention here that 1/50,000,000 of a milligram of radium, will still discharge a loaded electroscope. Maybe all these elements are not dead, maybe their atoms do undergo certain changes, but if so, these changes occur so slowly that they are inconceivable to any human conception. Now compare with these well known facts the knowledge we have gained from

a study of uranium preparations and of radium! We have learned of a spontaneous and continuous emission of rays, which affect the photographic plate! That means emission of energy, and we are able to measure this energy by the fact that these so-called rays apart from their effect on the photographic plate are capable of ionizing the air. But no emission of energy could possibly occur without creation of heat! But if an atom is sending out so-called rays, which will have an effect on the photographic plate, and ionizes the air, and produces heat, and all this spontaneously and continuously, this atom must be alive, and must be continually changing! And through this process the atom of uranium changes to the atom of uranium-X, and this uranium-X into another atom, ionium, which Soddy calls the parent of radium, and this ionium by emitting energy, begets the new atom called radium, this still possessing the mentioned properties of emitting rays, of ionizing and of producing heat. It was the belief of the alchemists that it was possible to transmute one element into another, and it was the height of their ambition to transmute, for instance, the atom of lead into an atom of gold! And adhering to our iron barred rules as physicist and chemist we laughed at their dreaming of such a possible transmutation of atoms! But here is an atom of uranium, emitting energy and by doing so changing to the atom uranium-X, uranium-X to ionium, and the ionium by emitting energy, changing to the atom radium. In other words, we see that the transmutation of atoms into other atoms is an established fact, and this spontaneous transmutation is the foundation of a new science, the science of radioactivity, and radioactivity may be defined as the property of elements by which groups of their atoms will spontaneously change into groups of other atoms.

Having rehearsed the most important fundamental principles of radioactivity, and having shown you how radium is begotten, I shall now try to show you the different transmutations of the radium atom itself with the necessary allusion to Rutherford's theory, as to how this transmutation takes place, and I shall try to describe to you the different properties of the different transmutation bodies of the atom radium.

The so-called Becquerel rays are known to consist of three kinds of different rays, called alpha, beta and gamma rays. In a short paper which I recently wrote during my stay in Germany, which paper I turned over for publication to my friend Dr. S. Lowenthal in Brunswick, after it had gained the approval of quite a number of radium authorities, I protested against this nomenclature, basing my objections upon the following consideration. In advancing new names we should choose them in such a way that the name suggests the most striking properties of the object considered, or if we cannot do this, we at least should avoid names which obscure by reminding us of properties of other already known objects, which are not the characteristic or essential properties of our new object. In this instance, speaking of rays we at once are reminded of the rays of the sun-

light, penetrating longitudinally with transverse swingings, and possessing the cardinal properties of reflection, refraction and polarization. But the so-called alpha, beta and gamma rays have nothing in common with the properties just mentioned. The so-called alpha rays are most infinitesimal corpuscles loaded with positive electricity, of most effective ionizing power, moving with a velocity of 10,000 miles a second. They are absorbed within a flight of three inches and they cannot penetrate a sheet of paper. Being charged with positive electricity they will be attracted by the negative (south) pole of the magnet. They have no transverse swingings, and they cannot be reflected, refracted or polarized. I suggested that this ray be called alpha particle, and for its writing sign I suggested an alpha with a plus sign after and above it. The advantage of writing it in such a manner becomes evident at a glance, if I mention to you that this alpha plus particle may lose its positive charge of electricity and therefore become a simple alpha, then it is already a transmutation body of the former alpha plus, it is no more subject to further transmutation, because it is deprived of its life, it is a dead body and absolutely identical with the atom which we find in the spectrum of the sun, and which is known as helium, and if you require a writing sign for helium it should be a simple alpha. The atomic weight of helium is 4. The alpha particles are identical with the canal or Goldstein rays of the Crookes tube.

Neither have the so-called beta rays anything in common with the properties of the sunlight rays. They cannot be reflected, refracted or polarized. They are a stream of negatively charged electrons having no mass or weight. They are attracted by the positive (north) pole of the magnet, and their velocity is about 300,000 Klm. or 36,000 miles to the second. Their power of penetration is about 100 times greater than that of the alpha particles, and they will penetrate aluminum 0.5 cm. These so-called beta rays are in all their specific properties identical with the kathode rays of the Crookes tube, although the velocity of the latter is only 1000-2000 miles a second. I therefore suggest that these so-called beta rays be named beta kathode electrons, to indicate their kathode ray nature, for short: The beta electrons, and their sign in writing should be a beta with a minus sign after and above. The so-called gamma rays which always accompany the beta electrons are identical with the Roentgen X-rays, but their power of penetration is very much greater than that of the X-rays. The gamma rays will penetrate a plate of iron of one foot thickness. They cannot be reflected, refracted, polarized or influenced by a magnet.

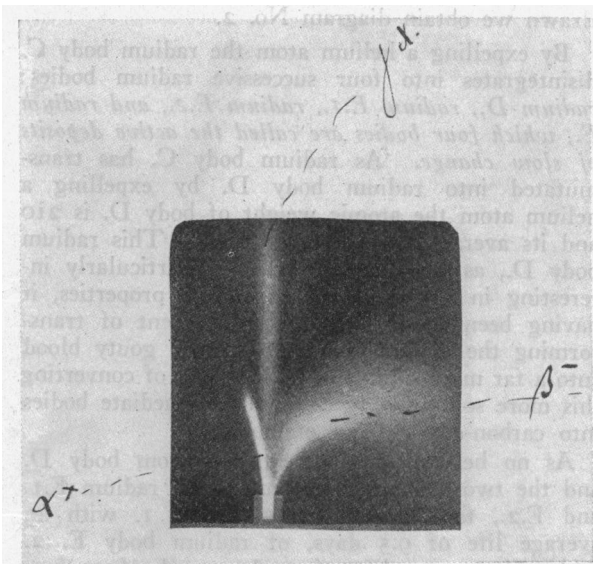
Picture No. 3.

As the name of the X-ray is universally accepted, I would suggest naming these so-called gamma rays gamma X-rays.

Following this suggestion I shall use in this paper the terms: Alpha particles, beta electrons and gamma X-rays.

Returning to the life history of radium let us

look at Rutherford's views regarding the transmutation of the radium atom, and in doing so it is best to begin with its oldest known ancestor, namely, uranium. Uranium possesses the greatest atomic weight of all elements, its atomic weight being 238 and its average life 7,500,000,000 years. In the course of disintegration the uranium atom will expel one atom of helium, that we called alpha and which we learned has an atomic weight of 4, and the result of the expulsion of this helium atom is the transmutation of the uranium atom with its atomic weight of 238, into a new body which is called uranium-X, atomic weight 234 average life 32 days. It is claimed that uranium-X does not emit alpha particles, but only beta electrons, but if no helium atom is expelled from uranium-X, the next transmutation body should have the same atomic weight as uranium-X, namely 234. Now there must be one or more intermediate bodies, so far unknown to us, for the next body of the transmutation series known to us has the atomic weight of 230; an unknown intermediate body having expelled an atom of the atomic weight of helium. The transmutation body with atomic weight of 230 has been named ionium by Boltwood. Its average duration of life is so far unknown to us. Since it is accepted that the expulsion of one helium atom will transmute this body into radium-atomic weight 226—Soddy called ionium the parent of radium. The so-gained transmutation body of radium has an average life of 2500 years and emits alpha particles only. Before proceeding to the offspring of radium itself, I will draw for you the genealogical tree of Rutherford and Soddy, showing the descent of radium, only adding to their original scheme the velocity of the alpha particles of the different transmutation bodies. The scheme is this: Diagram No. 1.



Picture No. 3—Shows the influence of a magneto upon the so-called rays emitted by Radium.

I have added to the Rutherford-Soddy scheme the expulsion of a helium atom from one of the intermediate bodies to explain graphically the atomic weight of 230, possessed by ionium. The

radium atom produces only alpha plus particles, which move with a velocity of 9600 miles per second and by expelling a helium atom (alpha) transmutes into a new body called emanation. As one helium atom was expelled from the radium atom the atomic weight of the emanation must be 226 (radium) minus 4 (helium) equals 222 (emanation). The average life of emanation is 5.3 days and it produces alpha particles only, these having a velocity of 10,400 miles per second. The emanation is a gas belonging to the same group as argon and helium, gases neither capable of absorption by any known reagent, nor possessed of any power of chemical combination, and they are called precious gases (Edelgase). By expelling a helium atom the emanation will form the transmutation body, radium A., which must have an atomic weight of 218, and which has an average life of 4.3 minutes. It produces alpha particles only with a velocity of 11,000 miles per second. By expelling a helium atom this body, radium A., begets the body radium B., with the atomic weight of 214 and a life of 28 minutes. The body radium B. produces weak beta electrons (beta minus) only, and as no helium atom is expelled the atomic weight of the following body in the series of transmutation, namely the body radium C., has the same atomic weight as the body B. namely: 214. Its life is figured out as being 30.5 minutes. *The radium bodies A. B. C. are called the active deposits of rapid change.* The radium body C. produces alpha particles of a velocity of 12,800 miles per second, the greatest velocity of the alpha plus particles we have so far encountered. The body radium C. also sends out strong beta electrons which are always accompanied by gamma X-rays.

In completing the genealogical tree previously drawn we obtain diagram No. 2.

By expelling a helium atom the radium body C. disintegrates into four successive radium bodies: *radium D., radium E.1., radium E.2., and radium F., which four bodies are called the active deposits of slow change.* As radium body C. has transmuted into radium body D. by expelling a helium atom the atomic weight of body D. is 210 and its average life about 17 years. This radium body D., as we shall see later, is particularly interesting in virtue of its therapeutic properties, it having been found capable by Gudzent of transforming the monosodium-urate of the gouty blood into a far more soluble body and then of converting this more soluble body through intermediate bodies into carbon-dioxide and ammonium.

As no helium atom is expelled from body D. and the two following transmutations radium E.1. and E.2., the atomic weights of E. 1. with an average life of 9.5 days, of radium body E. 2. with an average life of 7 days and of radium body F. must be 210. Radium F. is extremely interesting. It is identical with the radio-active body which Mme. Curie separated from the pitchblend before she discovered the radium, and which she called polonium. Its atomic weight as mentioned previously is 210, its average life 203 days, and it emits only alpha particles of a com-

paratively slow velocity of 10,000 miles per second. As alpha particles are emitted from radium F. the expulsion of a helium atom will bring the atomic weight of the following and last known radium body of the series of disintegration, the radium body G. down to 206, which is also the atomic weight of the element *lead!* *And as lead is always found to accompany uranium in whatever minerals the latter is discovered, the possibility presents itself, that lead may be the end link, the corpse of the uranium atom.*

We are in a position now to complete the graphic illustrations of the Rutherford-Soddy scheme. Diagram No. 3.

If radium bromide be dissolved in water, three-fourths of the radioactive power of the radium bromide is lost, because the escaping radium body called emanation, which is a gas, carries away three-fourths of the radioactive power, and if you examine this radium solution now as to its contents, you will find alpha particles only, no beta electrons and consequently no gamma X-rays. Now keep this radium bromide solution in a closed bottle in the dark or in the light, in the cold or in the heat, this radium bromide will produce its transmutation bodies, its radioactive power will increase every day and after thirty days this solution will have exactly the same radioactive power as had the radium bromide crystals before you dissolved them. Open your bottle and drive out the emanation by boiling your solution or evaporate all the water by boiling, so that you get back your crystals of radium bromide, and you will find that your radium through this procedure has again lost three-fourths of its radioactive power, and again only emits alpha particles, but after thirty days you will find that your radium bromide has recuperated to its full radioactive power, as if you never had changed its state of aggregation. Add chemicals and acids to it, do with it whatever you please, you never can alter its life, it will in spite of all manipulations constantly produce the same amount of energy through transmutation, losing weight it is true, but to a degree inconceivable to our conception.

You will wonder, how does the radium that has lost three-fourths of its radioactive power by our manipulations, regain its full power in 30 days? If you look through the magnifying glass of this little instrument, which is called the Spinthariscopescope, you will see a most wonderful display of scintillating bodies flying around like shooting stars. The display you see here is nothing else but alpha particles bombarding a little screen covered with zinc-sulphite. These alpha particles are shot out from the point of a needle that has been dipped in a radium solution and has been fixed about one-fourth to one-half cm. distance in front of the zinc-sulphite screen. Every time an alpha particle hits a zinc-sulphite crystal, the latter explodes and these explosions are the light effects which you see. You will readily understand that this display will come to a standstill as soon as all these zinc-sulphite crystals have been used up by the explosions, but if you replace the worn out screen by a new one the display will

go on till the new screen is worn out and so on for 2500 years. You can appreciate how small a quantity of radium is used in this little instrument, when I tell you that a sixtieth of a grain—one milligram—of radium, has been dissolved in probably a pint of water and the point of this needle has been only dipped into this extremely weak solution. And what you see here is practically the key to the understanding of radioactivity. What is happening here, the bombardment of the screen with alpha particles sent out by the radium, takes place in every atom of the radium, on the surface just as well as in the inner parts, no matter whether the radium is in solution or in solid form. Now we have heard that the penetration power of the alpha particles is a very limited one, it will not penetrate through a sheet of paper, or through three inches of air. It is plain therefore, that only alpha particles emitted from radium atoms of the surface can find a free outlet, and that any alpha particles emitted from the atoms of the interior of the solution or solid body will be held back and being radioactive and held back are a source of energy which increase the radioactive power of the specimen. If I now dissolve a quantity of radium bromide in water I set free these imprisoned alpha particles, hence the sudden drop in the radioactive power of the solution, and on the other hand by closing the bottle again and thus retaining in the interior of the solution the alpha particles the gradual restoration of the full radioactive power occurs in 30 days. This property possessed by radium of regaining its full radioactive power is a property of all radioactive elements and is the fundamental law of the conservation of radioactivity. Besides the principal properties of the alpha particles mentioned before, I have to make you familiar with another most important property of the radioactive elements, which again is most closely connected with the alpha particles.

Figure No. 1.

You will have noticed on the photographic plate where the piece of pitchblend photographed itself beside the wire clamps which were placed between the pitchblend and the photographic plate, two broad bands on the plate, which are photographs of two strips of zinc-oxide plaster, with which I bound the pitchblend to the plate, to steady my object. In spite of being pasted above the pitchblend, and in spite of being a substance, which rays would penetrate so easily as to give you a good picture on the plate, even if they had been placed between the pitchblend and the plate, you see here quite distinctly a photographic reproduction of the two strips. Now what happened in this instance is this: The alpha particles emitted from the radioactive pitchblend hitting this zinc-oxide plaster covered it with a deposit of probably millions of alpha particles with all their radioactive properties, and these have produced under conditions previously mentioned exactly the same beta electrons and gamma X-rays, as any radioactive element would under the same conditions. The alpha particles as you know could not have penetrated the two layers of paper the plate was wrapped in, so it could never have effected the

plate, therefore it must have been the effect of the beta electrons or gamma X-rays. These deposits will occur on any bodies within reach of alpha particles, and as the emanation gas, which as you know has an average life of 5.3 days and has a wider field for its flight than alpha particles, which are absorbed within three inches, and as the emanation as you know, emits again alpha particles, you can understand that I can effect deposits of alpha particles on all the walls, floor, ceiling and furniture of a big room, if I only have a sufficient amount of radium and the necessary time at my command; and this deposit will be radioactive. We therefore speak of radioactive deposits. If I now remove the spreading source, the radioactivity of this room will grow weaker and weaker by the dying off of the different radioactive transmutation bodies. Whilst the radioactivity of radium is a constant one, the radioactivity of this room must be a limited one, since it is induced by radioactive deposits of limited life.

If I chose for an experiment a quart of water and lead into the water radium emanation, I can make the water radioactive, strong or weak, just according to the quantity of emanation I let in, it now possessing all the properties of radioactivity, but for a limited time only since emanation loses its life in 5.3 days, but if I dissolve a particle of radium with a life of 2500 years in the quart of water the solution will remain radioactive for that number of years.

Having knowledge of the varied properties of radium and its different transmutation bodies, experimenters studied their stimulating and destructive effects on the lower and higher animals. They then applied them to human beings, traced their effects step by step through thousands and thousands of experiments, and I will give a brief synopsis only, of the conclusions arrived at through the experiments and investigations of the different scientists during the last ten years.

In discussing radium as a therapeutic agent, we will have to consider its properties in regard to its general influence upon the body, and in regard to its local effect. While the latter is due to the influence of its emitted so-called rays, that is, the alpha particles, beta electrons and gamma X-rays, the general influence on the body is due to the biological action of the radium emanation and its disintegration bodies, and this we will further consider. People have accepted for years that certain ailments of the human body are cured or at least beneficially influenced by certain natural springs, by drinking the water or by bathing in the springs. The water has been examined again and again and different ingredients made responsible for the curative results, but as the different springs showed different ingredients, though having the same curative reputation, no conception of a specific curative agent was possible. Furthermore, it was found that these waters bottled at the springs and shipped to the patients' homes, never had the effective value that they had at the springs, although the chemical ingredients had not changed and the waters were heated to their natural temperature. And so the layman, wandering every year to the

springs and finding there relief from his ailment, whilst he found no relief by drinking the same waters at home, formed his own theory, ascribing to supernatural and mystic powers the virtues which otherwise he could not explain. He imagined that there was a mystic power which came out of the springs and cured him; he called this mystic power the "spirit of the springs." He thought that his relief was due to his inhaling the spirit of the springs as it rose out of the water. This belief was the tradition of generations in ancient years and their good common sense told them to hold back the spirit of the springs by building little wooden houses over the spring. They sat in these little wooden houses to inhale the spirit and they got well! These little wooden houses have been torn down by scientists, who could not allow mystic superstition to interfere with their highly scientific way of using the waters for treatment! But during the last six months two beautiful pavilions have been erected and opened for the public, one over the spring at Teplitz, at the cost of 60,000 crowns, the other over the spring in Wiesbaden, at the cost of 60,000 marks, with the purpose of leading the spirit of the springs into the pavilions, and hundreds of sick people sit there for hours every day inhaling the very same spirit of the springs as people did hundreds of years before them, but the name of the spirit has been changed! For what these people inhale in these pavilions is called to-day radium emanation. It may be stated here that emanation is considered, if not the only, at least the most effective curative medium of the springs, and that the effective value of the water depends upon its degree of radioactivity. As it would have been a hard test to have proven the curative value of the emanation by separating it from the other spring ingredients, experiments were made by different scientists to produce artificial radioactive waters and to compare the curative results gained from these artificial waters with those of the natural thermal springs, and they found results equal and even better than those brought about by the springs.

The credit of investigating the effect of emanation treatment is undoubtedly due to S. Lowenthal, who in 1906 in a series of scientific and systematic investigations showed the influence of emanation upon the healthy and sick. He was able to show that the introduction of ten and fifteen thousand volt units of emanation into the body of a healthy person, had no effect whatever, neither subjectively nor objectively. Quite different, however, was the reaction in twelve cases of chronic rheumatism, eleven of which after drinking eleven to fifteen thousand volt units of radium water for one or two days experienced a swelling and increased pain, not only in the joints affected at the time, but also in the joints involved in former attacks, a reaction similar to the so-called "reaction" which the rheumatics experienced at the springs, a reaction which was always considered by the layman, as well as the physician a very favorable sign of a probable cure. Other investigations of Lowenthal in numerous cases have shown de-

cided cures and improvements with or without reaction.

On the ground of these experiences of Lowenthal the emanation treatment has been taken up universally in Germany and Austria, by the clinics and specialists for different diseases, and the following conclusion has been arrived at and enunciated by Paul Wichman. Cures or marked improvements by administering radium emanation, by inhaling, drinking, bathing, and by the use of radium compresses have been seen in the following affections: Chronic rheumatism of joints and muscles, chronic neuritis, neuralgia, shooting pains of tabes, chronic catarrh of the different parts of the body, sluggish chronic effusions, gout, certain female troubles as endo- para- and perimetritis of the acute or subacute forms. Accepting his statement, two most important questions require consideration: First, what are the possible properties of the emanation which bring about the cures of these morbid conditions? Second, as results have been obtained by compresses, drinking of radium water, bathing in the water, by the inhalation of emanation, which of these modifications is therapeutically the most effective?

Regarding the curative properties of the emanation many speculations presented themselves as to the possibility of bactericidal action, of a transformation of lecithin, of a direct alteration of toxins, of a production of H_2O_2 out of the waters of the tissues; but all these theories have been rendered improbable as far as the emanation is concerned. A very important step in the series of investigations was taken by Bergell and Bickel. These authors studied the influence of the emanation upon the ferments and found that the inhibiting influence of salt solution upon pepsin and pancreatin action was negated by the adding of emanation, in other words, that the emanation had actually actuated the ferments. Since by systematic investigations Löwenthal in co-operation with Wohlge-muth and Edelstein proved also the actuation of the autolytic and diastatic ferments, it has been accepted, that the biological action of the emanation and its disintegration bodies consist in an actuation of metabolic as well as of autolytic ferments. The great importance of autolytic stimulations is apparent in all conditions where morbid deposits have to be carried away.

The importance of the stimulation of metabolic ferments becomes great in those instances in which insufficiency of these ferments result in disturbances of metabolism. As gout is the best studied disease of metabolism, and investigators have added much to the understanding of the true nature of the disease, it will be readily understood that gout was chosen as the metabolic disease on which to try the therapeutic effects of emanation, with, I am glad to say, the happiest results. According to the investigations of Brugsh and Schittenhelm we accept as proven to-day, that gout is a disease of metabolism, brought about by a disturbance of the entire system of the ferments of the purinmetabolism, and this in such a way, that formation of the uric acid is delayed, as well as its further splitting up and its elimination. This leads to a

continuous accumulation of uric acid in the blood, a condition called urikamia.

Through the work of Gudzent we know to-day that uric acid can circulate in the blood as a salt only, indeed as monosodium-urate, and that this monosodium-urate exists in two isomeric forms; the lactam-urate, which is formed first, is more soluble but unstable and changes into the isomer; the lactim-urate, which is stable, but less soluble. The solubility of the lactam-urate is 18.4 mlgr. in 100 cm. serum according to Gudzent, while the solubility of the lactim-urate is 8.3 mlgr. only. It was found that as the monosodium-urate in gout circulated in the blood as the stable but very much less soluble lactim-urate, at times

to six weeks and in twenty-two out of these twenty-five cases the monosodium-urate had disappeared from the blood, in two cases tophi had disappeared altogether, and in other cases had grown decidedly smaller. Equally good results in gout with r. emanation by inhalation, drinking or bathing were reported at the last Balneological Congress in Berlin March 3rd to March 6th, 1911, by Furstenburg, Eichholz, Löwenthal, Kionke and Lackman. I have had a splendid opportunity to observe the results of the emanation treatment in gout and rheumatic affections at His's clinic in Berlin and Löwenthal's emanatorium in Brunswick. In three gouty cases in His's clinic I saw the onset of an acute paroxysm of gout during the session in

		ATOMIC WGT.	LIFE	VELOCITY of α PARTICLE
Diagram No. 1	Uranium	238	7,500,000,000 yrs	9,600 miles a second
	" X	238-4=234	32 days	No alpha particle
	Unknown Intermediate body	234	?	?
	Ionium	230	?	8,800 miles a second
Diagram No. 2	Radium	226	2,500 yrs	9,600 " "
	Emanation	222	5.3 days	10,400 " "
	Radium Body A	218	4.3 mins.	11,000 " "
	" " B	214	38 "	No α particle
Diagram No. 3	" " C	214	30.5 "	12,800 miles a second also emits β and γ Rays
	" " D	210	17 yrs.	No α particle
	" " E I	210	95 days	" " "
	" " E 2	210	7 days	" " "
	" " F	210	203 days	10,000 miles a second
	" " G	206		
	(Lead)			

the blood becomes supersaturated with the uric acid. By means of systematic experiments in a test tube, Gudzent found that one of the disintegration bodies of the radium emanation, the radium body D. will either retard the formation of the more insoluble isomer or transform the lactim-urate into a by far more easily soluble body, which later will finally be burned to carbondioxide and ammonium.

The test tube experiment was then transferred to actual test on gouty men, and emanation treatment by way of inhalation in the emanatorium was used on twenty-five gouty patients, their blood examined before the treatment showing the presence of M. S. U. The blood again was examined for M. S. U. after emanation treatment from three

the emanatorium. The paroxysms were promptly broken by atophan (phenylchinolin-carbonacid), which is given in a dosage of 0.5 to 1 gram four times a day with large quantities of water and bicarbonate of sodium, the latter being added to prevent renal colics by the rapidly excreted uric acid. As this reaction is not infrequent it would be wise to inform patients of a possible occurrence in the beginning of the treatment.

In a paper on gout read before the Anglo-American Medical Society in Berlin in June, 1911, P. F. Richter, one of the leading authorities on diseases of metabolism in Europe, after dwelling upon the treatment of gout, closed his address with the following sentence: "While in former

years we were not able to give our gouty patients any hopes as to a positive cure, we can safely today, after the introduction of the radium emanation treatment, assure our patients that gout ranks in the class of curable diseases." Very encouraging results have also been obtained by different clinicians in the treatment of the various acute and chronic rheumatic troubles of the joints, muscles and nerves. Very satisfactory results with few failures only, are reported in sciatica by Davidsohn, Fürstenberg, Gottlieb, Frankel, Kohlrausch and Mayer, Strasser and Selka and many others. Strasser and Selka, Gottlieb and Stern also report a favorable influence on the shooting pains of tabes. While Laquer and von Noorden do not obtain results in acute gonorrheal arthritis, quite favorable reports have been published by Nagelschmidt in this condition. Mostly cures or very marked improvements with only very few failures are reported in chronic arthritis by Löwenthal, Laquer, Riedel, Fürstenberg, Somer, Strasser, Sekla and many others. Quite as numerous are favorable reports by the authors mentioned above in sub-acute arthritis, in neuralgia and in acute and chronic neuritis. Löwenthal and Kemln reported favorably upon emanation treatment in myocarditis.

The good results obtained in chronic joint diseases naturally do not mean the restoration of destroyed joints, but even in such cases much relief of pain ensues. In a recent paper published by von Noorden and Falta good results are claimed in the treatment of acute and chronic rheumatism, in one case of Bechterew's disease, in rheumatic polyneuritis and in the treatment of the shooting pains and gastric crises of tabes, in sciatica, in angina pectoris, in insomnia and in obstipation.

Following the suggestions of Soddy to use the emanation by way of inhalation in lung affections, Bulling made use of this way of treatment in 112 cases of various affections of the respiratory tract with good results in 67 cases. The clinic of von Noorden and Neusser report the good effects of applications of radioactive compresses over the abdomen in tubercular peritonitis. I am able to report a case of tubercular peritonitis which was seen on the 2nd of May, 1911. The patient was emaciated to a skeleton, peritoneal effusion and extremely painful meteorism were present, and he was not able to keep any food on his stomach, diuresis 500-600 ccm. evening temperature 39.5° C. In the evening of the same day a radium injection was given under the skin of the abdomen. Diuresis on May 3rd was 1000 ccm.; patient could retain some food; evening temperature 37.2; patient more comfortable. On May 4th diuresis 1800 ccm.; patient ate better and could retain all of his food. Evening temperature 37.3°. Radium drinking water was added to the injection. After giving the boy the second injection on the evening of May 4th, I left him in the hands of his attending physician, receiving weekly reports of his progress. The last report, received on July 23rd, showed a gain in weight of 15 klgr., about 32 lbs., the boy was well and walking every forenoon and afternoon for one hour.

As to the question of the best way of adminis-

tering the radium emanation, either by drinking or bathing, or by inhaling the emanation gas in closed quarters—opinions are widely divided. The most important factor, is according to Löwenthal and Gudzent, to keep the emanation circulating in the blood as long as possible. Blood examination by Gudzent on patients in the emanatorium have shown that after inhaling the emanation gas for one-quarter of an hour only, the amount of emanation to the litre of blood was equal to the proportion of emanation in a litre of air in the emanatorium, and that after three hours of inhaling in the emanatorium the blood contained seven times this amount. The emanation circulating in the blood leaves the body in the expired air, and Löwenthal and Gudzent claim that the emanation introduced into the body by drinking and bathing will leave the body in too short a time to be of service. Eichholz, however, in opposing this suggestion showed by experiments that, if the emanation is taken in drinking water, but in a concentrated form, that is, in not more than 200 ccm. water on a *full* stomach, it will be slowly absorbed and circulate in the blood with sufficient duration to give as good results as are obtained by the inhalation method of treatment. Very good results, particularly in diseases of the pelvic organs, were obtained by Eichholz by giving his strong radioactive water in the form of small enema. Hypodermic injections of radium bromide dissolved in water will naturally throw emanation into the circulation until the solution is absorbed and used up; and inasmuch as the radium containing injections will emit alpha particles, beta electrons and gamma x-rays these injections will be particularly serviceable in the neighborhood of inflamed joints. The analgesic properties of the radium, due to its so-called rays, justify the application of radium compresses which contain a minimal amount of radioactive substance of long life, and they will replace the mud of the mud springs, whose therapeutic value is due to the amount of radioactive substance they contain.

San Francisco, Cal., Jan. 3, 1912.

In a still more recent communication (B. K. W. No. 47, Nov. 20), than those referred to, Gudzent published the results obtained in His's clinic by the use of radium emanation. He considers the inhalation of radium emanation in a close space to be far the best method of administration. He thus treated 50 gouty patients whose blood showed previous to treatment from 6-13.7 mg. monosodium-urate to 100 ccm. of blood. After 24 sittings in the emanatorium the blood of thirty-two of the fifty patients was free of uric acid, and after thirty-six sittings the blood of five more became uric acid free.

Further Gudzent whilst drawing attention to the poor results obtained by the commonly used methods in the treatment of arthritis in children claims marked good results from the radium inhalation in the emanatorium; on the other hand joint diseases occurring in aged people showed no improvement. Gudzent finds contrary to von Noorden and Falta, that patients with acute rheumatic fever are not favorably influenced by this form of treatment, but

chronic affections of the joints, muscles and fibrous tissues are greatly benefited except those of tubercular and luetic origin.

Repeatedly has he obtained good results in the treatment of acute chronic gonorrheal arthritis by a combination of inhalation treatment with the injection of radium solution around the affected joints.

THE ECONOMIC VALUE OF THE DECIDUOUS TEETH.*

By M. EVANGELINE JORDON, D. D. S., Los Angeles.

The environment of the American people has entirely changed within the life time of one generation and the connection between the environment and the teeth has not yet forced itself upon the minds of the public. A perfect dental equipment is one of the best gifts to mankind and environment is one of the great destroyers or preservers of the dental equipment. This was recognized when a parallel was drawn between the perfect denture of Sitting Bull who had lived the free life of the plains and had eaten the simple primitive food, and the broken carious teeth of his grandson who had suffered from the conditions of civilization.

Our change of environment has been slow but that it is just as fatal is shown by school examinations in different cities where the number of children needing dental care runs from 75% to as high as 97%.

The value of the teeth with regard to the state, that is, the effect upon the health of society at large and upon the taxes they must pay, is but little realized by the profession and is not even imagined by the laity. In his last report Dr. Ebersole, the chairman of the National Committee on Oral Hygiene, tells us that when the mouths of the school children are put into a healthy condition they can do 20% more work. The lack of such work, he estimates, is an annual loss to the taxpayers of the city of Cleveland of half a million dollars. Cleveland is one city in the United States, and conditions are similar in all communities.

This is only one way in which neglected teeth may increase taxes. The cost of caring for the young criminals might be greatly lessened by keeping the mouths of the poor children in a healthy condition. We should then have fewer young criminals because workers in juvenile courts find carious teeth one of the predisposing causes of viciousness and delinquency. Often these children become honest and upright when their mouths are made healthy. A step farther and the cost of maintaining prisons, courts, and penitentiaries would be lessened if there were fewer criminals growing up to fill them.

Hospitals are a great expense. Those who work in clinics for tuberculous children tell us that such children always have carious teeth. Go into any hospital and examine the mouths of the inmates and you will be satisfied that if their teeth had been kept in repair many of them would not need to be there.

Another heavy item of expense to the taxpayer is in maintaining asylums for the insane which each year are being more crowded. Some of the unhappy people would be well and self supporting if their teeth had been cared for, but now they are a tax upon the people.

And last but saddest of all, when old age is reached many people must be cared for by the state because they were unsuccessful in life. One fifth, or more, of their strength was lost by neglected teeth.

This is needless waste and is largely due to the fact that people think because the deciduous or baby teeth are to be shed that they need no care. Nothing was ever farther from the truth. These teeth are needed for use between the ages of two and twelve and under our present state of civilization every dollar spent in keeping the mouth in perfect health during this period brings better returns in health and strength than three dollars later on.

It was recognized very early in the study of the causes for carious teeth that the child who was raised at the mother's breast had better teeth, better shaped jaws, and was probably freer from adenoids and enlarged tonsils, than the bottle fed baby. It remained for dentists practicing exclusively for children to discover the very serious results that may be traced to bottle feeding. The first of these is the early decay of the teeth and the second is the deforming of the jaws. Many children begin to suffer with carious teeth before the second year. This may usually be traced to the lactic acid action upon the upper incisors of the children who had been fed upon bottle food that is too sweet, such as condensed milk, goat's milk, etc. In these cases a stain appears upon the teeth during the last part of the first year and in a few months these stained areas deepen into cavities often causing the teeth to be broken down to the gums by the middle of the third year. If the child has care the abscess which follows the growth of the cavity and the death of the pulp may be treated and the tooth filled and restored to usefulness.

My records show many such cases of children ranging from eighteen months to two and one half years of age. Each of these children needed besides such treatments several small fillings in other teeth which if neglected would have gone through the same destructive stages of inflammation of the bacteria invaded pulp, its death and supuration, and later alveolar abscess, followed by a necrosed area of the alveolar process surrounding the root.

* Read at a joint session of the Los Angeles County Medical Association and the Los Angeles County Dental Association.